VOL. VI. NO. 2. 1959

OCEANUS

EDITOR: JAN HAHN

Published periodically and distributed to the Associates of the Woods Hole Oceanographic Institution and others interested in Oceanography

J. H.

"THE WAY of a ship at sea." No matter how much support for oceanography may increase (we hope), nor how much instrumentation will improve, in the final analysis oceanography will depend on the will and ability of men to go to sea and do their work. "Man is not a sea-going animal," Columbus O'D. Iselin wrote many years ago.

Merchant ships now can be guided to avoid the worst gales and the highest waves, thanks to oceanographic and meteorological knowledge. Studies started at the Institution are beginning to lead to more sea-kindly vessels. Our ships, however, may always have to undergo uncomfortable conditions in our efforts to acquire a full understanding of the oceans.

EDITORIAL

Vol. VI, No. 2, 1959.

Since the publication of the report: "Oceanography 1960-1970", by the Committee on Oceanography of the National Academy of Sciences-National Research Council, we have been overwhelmed by attention and requests for information on oceanography. This most welcome notice culminated in a visit, during the first two days in June, by the subcommittee on oceanography of the House Merchant Marine and Fisheries Committee. A hearing was held at the Institution attended by Congressmen: George P. Miller, (D-Cal.) Chairman; James D. Oliver, (D-Maine); Gerald T. Flynn, (D-Wisc.) and Hastings Keith, (R-Mass.) Accompanied by the Chief Counsel of the Committee, Mr. John Drewry and two U. S. Navy representatives, Capt. R. Holden and Cdr. Stan Freeborn Jr., the Committee members were informed of our work and given a tour of the Institution.

A friendlier Congressional Committee hearing could not have been expected. Dr. Paul M. Fye and staff members presented our case and urged congressional support for a steady advance in all phases of oceanography.

"Rep. Miller said the visit had confirmed his personal feeling of the need for greater expenditures in studying the basic facts of the ocean." (Providence Journal).

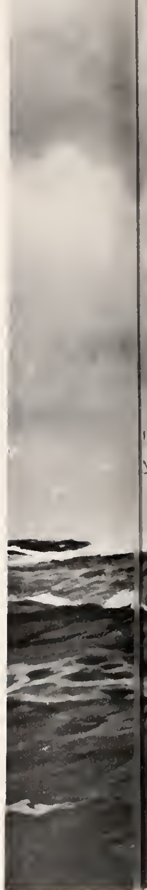
"The public can help, too, by indicating to their legislators a continuing interest in advancement of the sea sciences." (Standard Times, New Bedford.)

C. SPOONER

New Ships

J. R.

The ARIES off Bermudo, ot the stort of her first voyoge to Woods Hole.



G. BOLTZ

The CHAIN, 213 feet long, is the largest ship we have operated. She corries o crew of 38 and 28 scientists.

Artist's view of a new $3,375,000 research vessel that the Institution hopes to acquire.

ONE OF THE HIGHLIGHTS of the Congressional Hearing at Woods Hole was the announcement of plans for a new research vessel to replace the ATLANTIS. Drawn up by the Institution's Ship Design Committee, headed by Mr. Francis Minot, the designs are being prepared by Associate, M. Rosenblatt and Son of New York.

Last November, the Office of Naval Research provided us with an ex-Navy submarine salvage vessel, the CHAIN. The first of three ships from the "mothball fleet" to be converted for oceanographic institutions in the U. S., the CHAIN represents a stop-gap move to replace present-day, outmoded ships until funds become available to build ships designed for oceanographic research.

Through a generous gift of Associate R. J. Reynolds, we acquired the 93′ ketch ARIES, early this year. She has been carefully converted and has sailed for Bermuda where, for the next two years, she will study ocean currents with the aid of Swallow buoys. *(see page 20)*.

E. R. BAYLOR

"Wait for the return roll" cautions Nat Corwin as a 50 gallon Bodman sampler hits the side of the CRAWFORD. Large samples are needed for radioactive analysis of seawater.

Bostwick H. Ketchum

Plankton biology and - - - the Development of Atomic Energy

Radioactive contamination of the oceans calls for an understanding of the food cycle in the seas.

AS the production of the industrial energy from atomic reactors develops in the world it is inevitable that some radioactive isotopes will be added to marine waters. Measurable amounts of fission product radioactivities from fall-out are already present in the surface waters of the North Atlantic Ocean, and probably in all oceans. In England, waste radioactive materials are being added to the Irish Sea, and the permissible quantities of discharge have increased over the last few years from a few hundred curies per month to the present limit of 10,000 curies per month.

If it were not for the biological population in the sea, man would have little interest in its radioactive contamination. Centuries, combined with very foolish practices, would be required before the radioactivity of sea water could be raised to a level which would be of direct menace to man himself. This is partly because the ocean is one of the least radioactive environments in the world today. For example, a large fish living at 300 feet of depth in the ocean receives only about one seventh of the natural radiation that a man living on a granite mountain does. Even man in a ship at the sea surface receives only a quarter of the radiation of our mountain dwelling individual.

However, the ocean teems with life, and through a complicated food chain, supports a large supply of food for man. Some elements are concentrated many-fold by life processes in the sea, and these elements may be transferred as the smaller creatures are eaten by the progressively large ones. If these elements were radioactive isotopes this process could result in a much higher concentration of radioactivity in the living organisms in the ocean than is present in the water. Our knowledge of the problems involved in the addition of radioisotopes to the ocean, is very incomplete. Filling the gaps in our knowledge emphasizes again the need for intensified research in all problems concerning the vast expanses of the oceans.

Intensive Studies

For three years we have been conducting an intensified study of the plankton populations in the oceans; a necessary first step in understanding the complex relationships among organisms. The microscopic plant cell is the living matter most intimately exposed to the chemicals dissolved in the water, and it is its ability to assimilate some of the elements in high concentration within its body which makes all life in the sea possible. Although individual plankton organisms are small they are vastly numerous and make up the major part of the living matter in the sea. It was estimated by George L. Clarke several years ago, that it takes about 10,000 pounds of the microscopic plant life (phytoplankton) in the ocean to produce one pound of fish harvested on George's Bank off the New England coast.

Just as a pasture must produce far more weight of grass than can be harvested as milk or beef so must the sea produce a vast excess of plants to compensate for the losses and inefficiency of the biological process.

The photosynthetic process depends upon the chlorophyll in the plant cell and the sunlight which enters the ocean. In the clearest oceanic waters there is adequate light to depths as great as 300 feet or so for the plants to photosynthesize and produce organic matter. In coastal waters, however, the turbidity of the water limits penetration of sunlight so that in a harbor the plants may have inadequate light at 10 feet of depth.

As on land, the productivity of the ocean depends upon the fertility of the waters. The same fertilizing elements are required. Some of these are present in great excess, but phosphorous and nitrogen are nearly exhausted in the surface layers as a result of plant growth. To evaluate the fertility of the seas, therefore, it is necessary to study the distribution of these essential elements and to evaluate the rate at which they become available to the plants through vertical mixing of the water column and through the decomposition of plant and animal materials.

> *Dr. Ketchum,* senior oceanographer, is one of the leading oceanographers in the field of plankton ecology. He is in charge of the investigations in this field at the Institution. Dr. Ketchum has a farm in Vermont, the only New England State without a sea border.

The Program

Our efforts have been directed towards understanding the conditions in the sea which determine the growth and photosynthesis of the microscopic plants, or phytoplankton, and which ultimately control how much animal life can be supported. For our observations at sea we have selected a line of stations extending from Montauk Point, Long Island, to Bermuda. This selection includes a range of depth and of environmental conditions which would be difficult to equal in any other part of the world. At the inshore stations the environment is typical of coastal waters, freshened by rainfall and run-off from the rivers, turbid so that adequate light penetrates to depths of 100 feet or less, but shallow enough so that in the wintertime the mixing column extends from top to bottom. Off the edge of the continental shelf the surface waters still reflect the coastal influence but the deep waters are typically oceanic in origin and character. A crossing of the Gulf Stream is also provided in this section. The stream carries waters which are tropical in origin and contain a unique biological population. Seaward of

the Gulf Stream is the Sargasso Sea, which is commonly called the desert of the North Atlantic ocean. Here the illuminated zone is at its deepest down to 300 feet. In the summertime the mixing is much shallower than the illuminated zone but in the wintertime it extends much deeper to about 1,200 to 1,500 feet so that the phytoplankton organisms spend a considerable proportion of their time in the deeper layers with inadequate light. The selection of this line of stations for our field studies thus represents a wide range of conditions and essentially reflects the use of the ocean as an experimental system in which the conditions of the experiment are set and determined by nature.

Work At Sea

To present the types of observations made in this program let us describe the bustling activity while the ship is stopped on one of the deep stations. Some of these deep stations are predetermined geographical points, and the ship's officers stop the ship and inform the scientists that we are "on station". Others however, are selected for specific water characteristics. For example, the station in the Gulf Stream is not always in the same geographical location since the Gulf Stream is never in the same place. Repeated bathythermograph observations are made, and the station is occupied when the temperature conditions in the water down to a depth of 900 feet indicate clearly that we are in Gulf Stream water.

After arrival on station the first activity is to make what is known as a shallow "cast" which involves sending a series of bottles attached to the hydrographic wire to a depth of 300 feet so that the plant population in the upper, illuminated zone, can be evaluated. Some of this water is fil-

The grass of the sea
and a grazing copepod

R. L. GUILLARD, D. PHILPOTT,
S. WATSON, E. R. BAYLOR

tered and preserved for the determination of its chlorophyll content; other parts of each bottle are used for the direct determination of the rate of photosynthesis. This is done either by measuring the change in oxygen in samples after exposure for a known time to a standard light intensity or by adding radioactive carbon to the sample and determining the amount assimilated by the plant cells and built into new organic material.

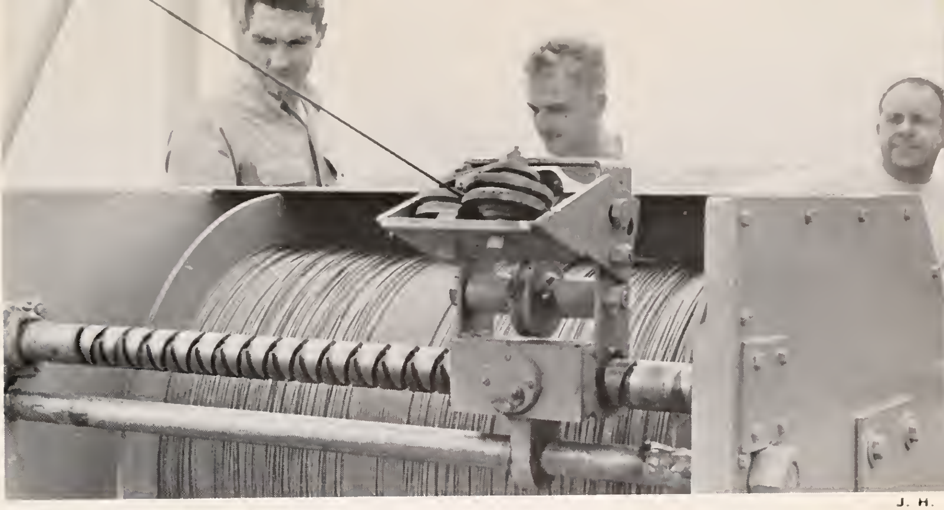
While these samples are being filtered and analysed another cast is already on its way down. This cast may contain a dozen or so of the well known Nansen bottles spaced at intervals along the wire to depths of 1,500 feet. Reversing thermometers are attached to each bottle so that we obtain an accurate measure of the temperature at each depth. When the cast is down, a wait of five minutes is necessary to allow the thermometers to come to equilibrium with the temperature of the water. Then a metal messenger is sent, tripping the series of bottles so that they capture the water and can be returned to the deck. Several analyses are made on the water obtained in this way. The oxygen is measured immediately on board, but we do not have time to complete other determinations. Samples for salinity and for total phosphorous are bottled and brought back to Woods Hole. Since the organisms living in the water would change the concentration of nutrients in the water during the storage these samples are placed in plastic bottles and frozen to stop biological activity. These samples are also brought home for analysis.

While the group in the ship laboratory are bottling the samples, determining the oxygen content and reading the thermometers the winch is again busy lowering a small plankton net to the bottom of the illuminated zone so that we obtain a sample of the plankton in these upper layers of the water column. This fine meshed nylon net retains the larger members of the plant population and also catches many of the smaller zooplankton organisms. These samples are also frozen to prevent changes. In Woods Hole they are thawed, the species identified and the chlorophyll content and other plant and animal pigments are determined.

Deep Cast

Meanwhile the time has come to send down the deep hydrographic cast. The deepest sample in this cast may be collected at 15,000 feet, or nearly three miles below the ship. This water is treated the same as the shallower hydrographic cast, but the time required to collect the samples is considerably longer. To place the sampling bottles on the wire and to lower it on its three mile journey takes nearly an hour with a seasoned observer when all goes well. If the seas are rough or if other complications arise the time may be longer. Even for the messenger to fall through the water on the wire on its three mile journey takes half an hour. Finally, however, these samples are retrieved, bottled and stored.

The final operation on the station is a plankton tow which is taken with the ship under way at slow speed. A larger and coarser net is used for this tow since we want as large as possible a sample of the animal plankton, and have already obtained our necessary samples of the plant population. With the ship proceeding at two knots, this net, which is about three feet in diameter and six feet long is lowered slowly to reach a depth of about 600 feet. To reach this depth, since the net is streaming



J. H.

THE HYDROWINCH on board the CRAWFORD. L. to R. Capt. David F. Casiles, 1st mate J. Q. Bumer and 2d engineer J. A. Kostrzewa, during a lowering of Nansen bottles.

out behind the ship, about a thousand feet of wire has to be paid out. The net is then slowly retrieved by hauling in with the ship still steaming at about two knots. In half an hour this sample is also aboard and the work on station is completed some four to five hours after our arrival.

On some stations other activities are added to the program. For analysis of the radioactivity in the seawater much larger samples are needed than can be obtained by the standard sampling bottles. So, a special sampler capable of collecting from thirty to fifty gallons of water is lowered successively to different depths. With such large samplers only one is lowered at a time since it is impossible to put several on the wire. Thus, while a standard hydrographic station can be completed in four to five hours, the large sample stations may take 24 hours or more.

While proceeding to the next station the scientists have an opportunity to complete the analyses done on board, to check over the results of the station, to calculate the depth of the various samples, and to prepare for the next station which is only a few hours steaming away. If the ship were to steam directly for Bermuda it would take about two days and a half following this route, but it takes six or seven days because of the 15 to 18 stations which have been occupied along the way.

Shore Work

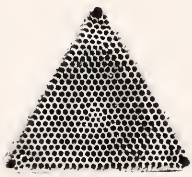
After the ship returns to port the work is barely begun. The salinity and nutrient determinations must be completed, the chlorophyll must be extracted from the plant cells and measured, the results of the photosynthesis experiments require laboratory analysis and the plankton must be sorted and identified in order to know what species of plants and animals are living in the water. Just as on the land, there are marked seasonal variations in the populations, with the spring bloom, the fall flowering, and the mid-winter dormancy. Such cruises must be repeated at various times of year to evaluate the changes in conditions and the resultant changes in the populations. Never in the sea does one find completely barren water. Even in midwinter the populations, though small,

are still actively carrying on their life processes. On the other hand, even in the subtropical conditions around Bermuda conditions are more favorable for growth at some times of the year than at others so that peaks of population are observed when conditions are just right.

Final Aims

The objectives of the program are to determine what the conditions are which constitute "just right". Much progress has been made in understanding the productivity of the ocean but many questions remain unanswered.

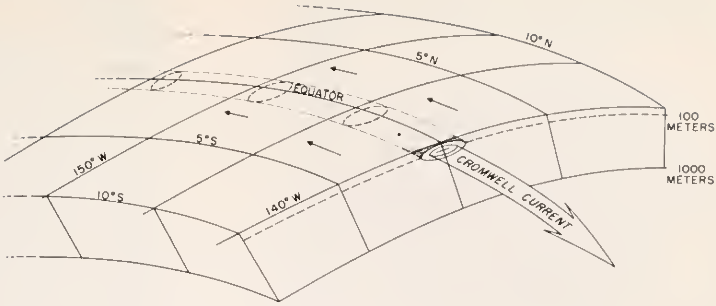
Knowledge of this complicated process is essential before we can evaluate the oceans as a greater source of food for the expanding world populations. Moreover this information is urgently needed before we can evaluate the effects of radioisotopes which may be added intentionally or inadvertently to the sea in the future. We are convinced that any radioactive contamination of the oceans should be done only under rigid control, and with full scientific understanding of its effects.



"Five physical oceanographers from the internationally known Woods Hole Oceanographic Institution have been appointed professors of oceanography, part-time, at the Massachusetts Institute of Technology, Dr. George R. Harrison, Dean of the School of Science, announced today" (from the M.I.T. Office of Public Relations, release for May 20, 1959).

Those appointed were: Dr. Columbus O'D. Iselin, Dr. Willem V. R. Malkus, Henry M. Stommel, and Dr. William S. Von Arx. Dr. J. B. Hersey was appointed associate professor.

Dr. Robert E. Shrock, head of the department of geology and geophysics at the M.I.T., stated: "The inclusion of oceanography as a major part of the M.I.T. curriculum is vital to the advancement of the study of all earth sciences."



C. O' D. Iselin

New Discovery in Physical Oceanography.

A countercurrent observed in the Pacific poses theoretical problems.

A new type of relatively swift current has recently been located along the equator in the Pacific flowing towards the east. The doldrum belt lies somewhat to the north of this current so that it flows against the prevailing local winds. Maximum velocities of about 150 cm/sec (roughly 3 knots) are at a depth of about 150 meters and extend for as much as 30 miles either side of the equator. This core of high velocity subsurface flow is imbedded in weaker easterly flow, extending from just below the surface down to a depth of about 400 meters and from Lat. 2°N. to about Lat. 2°S. This is an entirely separate current from the Counter Equatorial Current at about Lat. 8°N., which is shown on all surface current charts. It was first named the Equatorial Under Current, but it is likely to be known in the future as the Cromwell Current in honor of the oceanographer, Dr. Townsend Cromwell, who was one of the first to detect it and who recently was killed in an airplane accident. The deeper water under the Cromwell Current has been shown to be moving slowly (about 10 cm/sec) towards the west.

Since Cromwell's death the current has been traced for about 2,000 miles along the equator in the Pacific and during the past year an extensive series of sub-surface current measurements has been secured by Mr. John Knauss of the Scripps Institution of Oceanography across the equator at longitude 140°W. These set the volume of the water being transported eastward at about thirty million cubic meters per second or roughly one third of the maximum total volume of the Gulf Stream passing New Eng-

land. That this major current has escaped detection for so long is due to the fact that it is only weakly represented at the surface.

Here at Woods Hole we have naturally been interested in the question of whether or not a similar subsurface current is present along the equator in the Atlantic. There is indirect evidence that the Atlantic has no such current. An analysis of near surface salinity distributions in the tropical Atlantic by R. B. Montgomery in 1938 shows several streams of near surface water with a westward and northward component at the equator. If a counter current does exist in the Atlantic at the equator it would have to be very much shorter than the newly discovered Pacific current.

Existing theory is quite incapable of accounting for the Cromwell Current. Its peculiar characteristics must be associated with the disappearance of the Coriolis Force at the equator. The hydraulic head to maintain this subsurface, swift flow is probably supplied by the piling up of the near surface tropical waters on the western side of the ocean by the Trade Winds. If this is true, such a current would not be present in the Indian Ocean where the winds reverse themselves seasonally.

The new subsurface current measurements from near the equator in the Pacific present physical oceanographers with a major problem. It has been known for some time that weak counter currents are usually present on either side of most major ocean curents, but in these the velocity decreases gradually with depth, as indeed it does in most ocean currents. To account for a sharp velocity maximum at a depth of only 150 meters requires a completely new concept.

The counter currents, whatever their causes, are of extreme biological importance. If they did not exist, the entire population of the near surface waters would be living on a "one way street". It would be the fate of all pelagic organisms to end up in an inhospitable environment. The counter currents take some of them back to where their ancestors started from. Although obviously an important aspect of oceanic circulation their causes have remained obscure. The Cromwell Current is a new piece to be fitted into the puzzle.

Dr. Iselin, former director, occupies the Henry Bryant Bigelow Chair of Oceanography.

NOTICE

at the M.I.T. Faculty Club

3.45 PM MAY 29, 1959 FRIDAY

A COMPETITION of

THEORIES

of the

EQUATORIAL UNDERCURRENT

ALIAS "THE CROMWELL CURRENT"

FEATURING:

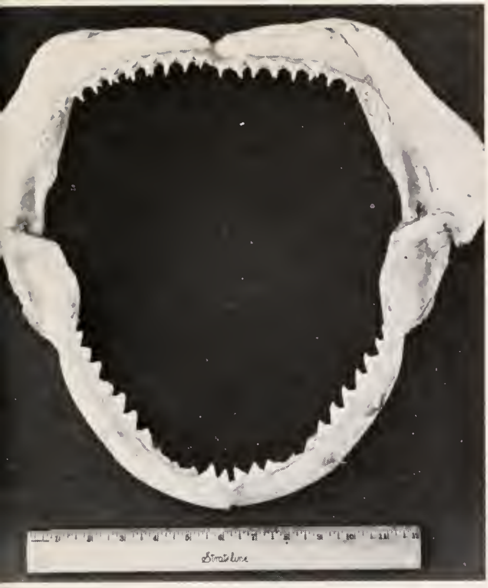
DR GEORGE VERONIS, PROFESSOR J. G CHARNEY, & HENRY STOMMEL ESQ, EXHIBITING THREE DIFFERENT MODELS, EACH IN ONLY FIFTEEN MINUTES

and

PROFESSOR W. V R MALKUS PRESENTING THREE ANTIMODELS, EACH IN ONLY FIVE MINUTES.

BREATHLESS PERFORMANCE!

ADMISSION FREE



C. SPOONER

Oh - why can't we ?

SHARKS MAY HAVE several series of teeth in actual use and whole rows of teeth in reserve which move into place, not only when one tooth has broken off, but continuously throughout the shark's lifetime.

The reserve teeth are shown clearly in our photograph of the jaw of a dusky or shovelnose shark (Carcharinus obscurus) caught in the Gulf of Mexico. This is not the whole "stock" for a life span. New rows are developed in a deep dental groove along the inner margin of the jaw. From one to four series of teeth may be in actual use and from two to seven rows in reserve. In the upper jaws the reserves are lying with the points up, in the lower jaw with points down.

The foremost or outer teeth are constantly moving outward and drop off. Since shark's teeth are imbedded in the gums and not in sockets they have no trouble shedding the teeth. Apparently teeth are not often broken under natural conditions but if this happens a new one takes its place from the reserves. Teeth are shed frequently enough. One rarely finds that they are worn down to any extent. Aquarium observations have shown that it takes from two days to a week for an individual tooth to become detached. As the shark grows, the reserve teeth gradually increase in size, although little or not at all in numbers across the jaw.

In some species, such as our common spiny dogfish, the teeth are not spaced apart but form a continuous interlocking cutting edge. In these sharks, teeth do not fall off individually but in a whole band either on one side of the jaw or simultaneously on both.

Wm. C. S.

Ed. Note:

The above and many other interesting infarmotion moy be obtoined from Dr. Bigelow ond Mr. Schroeder's "Fishes of the Western North Atlantic", Part one, Memoir Seors Foundotion for Marine Reseorch, Number I. New Haven, 1948. 576 pp. This book, as well as the authors' other standard works, makes interesting reading and is full of informotion of use not only to the scientist but also ta the sportfishermon and the loyman.

Associates News

THE SEVENTH ANNUAL DINNER meeting was held at the American Museum of Natural History on Friday, May 12. Professor Harrison Brown, Chairman of the Committee on Oceanography of the National Academy of Sciences was the distinguished guest speaker. Professor Brown spoke on "Oceanography 1960-'70", the Report which has raised national interest in the science. A copy of the Report has been sent to all Associates. We are proud that the Associates through their support, have evidenced their awareness of the importance of oceanography long before the nation was awakened to its value.

New Corporate Associates

AMERICAN MACHINE AND FOUNDRY COMPANY
BENDIX AVIATION CORPORATION
DOUGLAS AIRCRAFT COMPANY, INC.
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New Life Members

Mr. and Mrs. Henry A. Morss, Jr., Cambridge, Mass.
Mr. and Mrs. Richard J. Reynolds, Sapelo Island, Georgia
Mr. and Mrs. Oscar Straus, New York, New York

Gifts

At the end of 1958 we received monetary gifts from several Associates and funds to replenish the "Lou Marron Science Fund".

Associates' Fellowships

The Educational Policy Committee announced that the following were recipients of the 1959 Associates Fellowships:
David A. McGill, Zoology, B.S. ('52) Bucknell University, M.A. ('56) Columbia University, presently a research assistant at the Institution. John S. Reitzel, Geophysics, B.A. ('52), M.A. ('58) Harvard University. Graduate student at Harvard. John S. Farlow III, Geology, ('57) Harvard University. Graduate student at Johns Hopkins University.

Industrial Aid

ANTI-SUBMARINE WARFARE (ASW) programs at the Grumman Aircraft Engineering Company (a corporate associate) have been greatly extended

during the past year and a half. The Grumman support in these ASW areas ranges from research in underwater physics and other related phenomena to flight test and development work with actual Fleet units.

To further Grumman's knowledge in the ASW field, Robert L. Erath of the Research department, is at the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts, for a six-month educational program. Purpose of the training is to learn the latest developments in underwater sound techniques and obtain the most recent information concerning the physical properties of the ocean.

The program is designed so that Erath will work closely with the Woods Hole scientific staff on their current projects, and acquire his knowledge through active participation in the field. He will also have the opportunity to make one or more cruises and thereby receive first-hand experience with the latest transducer systems, indicators, recorders and listening devices.

Manganese Nodules

Known for many years, the manganese bottom deposits recently have been widely discussed.

THE OLD, and for quite some time unpopular notion that manganese nodules on the sea floor may result from biological activity has recently been revised by Dr. John W. Graham, geologist on our staff. His findings of a number of organic compounds in some nodules from the Blake Plateau (off the Carolinas) aroused his curiousity in the subject. Subsequent work has uncovered the facts — never emphasized before — that the Challenger Expedition (1873-76) found most manganese nodules in the coldest bottom water, and that no nodules have been found in the Mediterranean and Red Sea where the bottom water is relatively warm. These facts are most simply explained by the notion that a manganese concentrating organism, supported by a starvation diet, must live in a cold environment, otherwise it would "burn itself up".

The food that this postulated organism consumes is a subject of fascinating speculation. It seems reasonable that the food consists of metabolically useful organic materials associated with heavy metals not normally soluble in sea water. The organism utilizes the organic portion for life processes and rejects the rest which then accumulates as the well-known complex mixture of manganese, iron, nickel, cobalt and copper hydrated oxides, along with smaller quantities of a number of other metals found in manganese nodules.

Preparations are now being made to search for the suspected organism. It is conceivable that it might be cultivated and possibly used, some day, to concentrate valuable metals from the sea.

Apart from participating in a number of cruises, this is Dr. Graham's first contribution since joining the Institution. He stated that his nodule work is just as exciting, and possibly will become as controversial, as the work he did during the previous ten years on the subject of rock magnetism at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.

* See photos, page 31, Oceanus, Vol. VI, no. 1.

Beards, Salts and Decimal Places

Francis A. Richards

Seawater is a dilute solution of salts in which the major variable is the amount of water.

ALTHOUGH the beard of the gentleman shown here might identify him as having recently returned from an oceanographic cruise, he never, so far as we know, went to sea in the pursuit of science. Beards were the fashionable rule, not the post-cruise exception, in his day. In spite of never having gone to sea, William Dittmar, F.R.S.S. L. and E., Professor of Chemistry at Anderson's College, Glasgow, was one of the early giants in oceanography. His importance to the science stems from his analyses of seventy-seven samples of sea water, collected during H.M.S. CHALLENGER'S 1873 - 1876 round the world cruise. These samples were entrusted to him by Sir C. Wyville Thompson, scientific leader of the Challenger Expedition. Dittmar's methods and results were not only a classical demonstration of accuracy, but they formed the basis for one of the most important tenets of oceanography — that of the constancy of composition of sea water, or Dittmar's law.

Dr. Redfield has more recently restated this principle by defining sea water as a dilute solution of salts in which the major variable is the amount of water. It tells us that all sea water is essentially similiar insofar as the kinds of major constituents are concerned (chloride, bromide, sulfate, bicarbonate, magnesium, calcium, strontium, potassium and sodium ions), which comprise 99.8 to 99.9% of the total dissolved matter, and furthermore that these ions occur in the same relative amounts in all sea waters, although their total concentration may vary considerably.

On this tenet depends the validity of Knudsen's Hydrographical Tables relating the chlorinity, salinity and temperature of sea water to its density, relationships between electrical conductivity and salinity, computations of the solubility of the atmospheric gases in sea water, and a host of other oceanographic parameters.

Dr. Francis A. Richards, chemical oceanographer, has been with the Institutian since 1950. He is leaving us this summer to accept the appointment of Associate Professar af Oceanagraphy at the University af Washington.

Dittmar was German born (in Umstadt near Darmstadt, April 15, 1833) and German trained. That he became an assistant to Bunsen proclaims his relationship to the great school of North European analysts which laid down so much of the foundation for modern chemistry. Dittmar first removed to Edinburgh, in 1861, but returned to Germany after eight years, lecturing in meteorology at the Agricultural College at Poppelsdorf. In 1872 he returned to Edinburgh, and was appointed Professor at Glasgow in 1874. He lectured as usual on the morning of February 9, 1892, but returned home, feeling unwell in mid-day, and died at 11:30 that night.

Dittmar's analytical results now have to be modernized because of our better knowledge of atomic weights, but no inaccuracies in his values for the ratios of the major constituents of sea water have been found in the open oceans. However, new methods for determining salinity by means of the conductivity bridge* have introduced a new order of precision into oceanography, and it may now become necessary to reinvestigate Dittmar's values to "one more decimal place".

The caricature here reproduced was kindly supplied by Drs. Sheina Marshall and A. P. Orr, after their recent visit to Woods Hole. It originally appeared in the December, 1878 issue of "The Bathe".

* See article: "The Salinometer" in this issue.

National Merit Scholars

Two Cape Cod High School students who received unusually high ratings in the National Merit Scholarship eliminations were selected by Dr. Fye to be employed this summer.

Miss Sara Lee Morin of Orleans High School will assist Prof. Mary Alys Plunkett, while David Hirschfeld of Lawrence High School, Falmouth, works with Dr. W. S. Richardson. A third student Miss Jean McGilvray of Lawrence High School, also eligible, has worked at the Institution in past summers and had already been promised employment.

Science Fair Winners

A cruise on the R.V. BEAR is to be the reward for three Massachusetts Science Fair winners. The three were selected by Commander J. A. Sharpe of the Office of Naval Research, U. S. Navy. They are: Paul Elterman of West Roxbury; John W. Miller of Springfield and Allan Ramo of North Abington.

J. H.

A tagged white marlin

Of Tunas, Marlins and Wahoos

Frank J. Mather, III

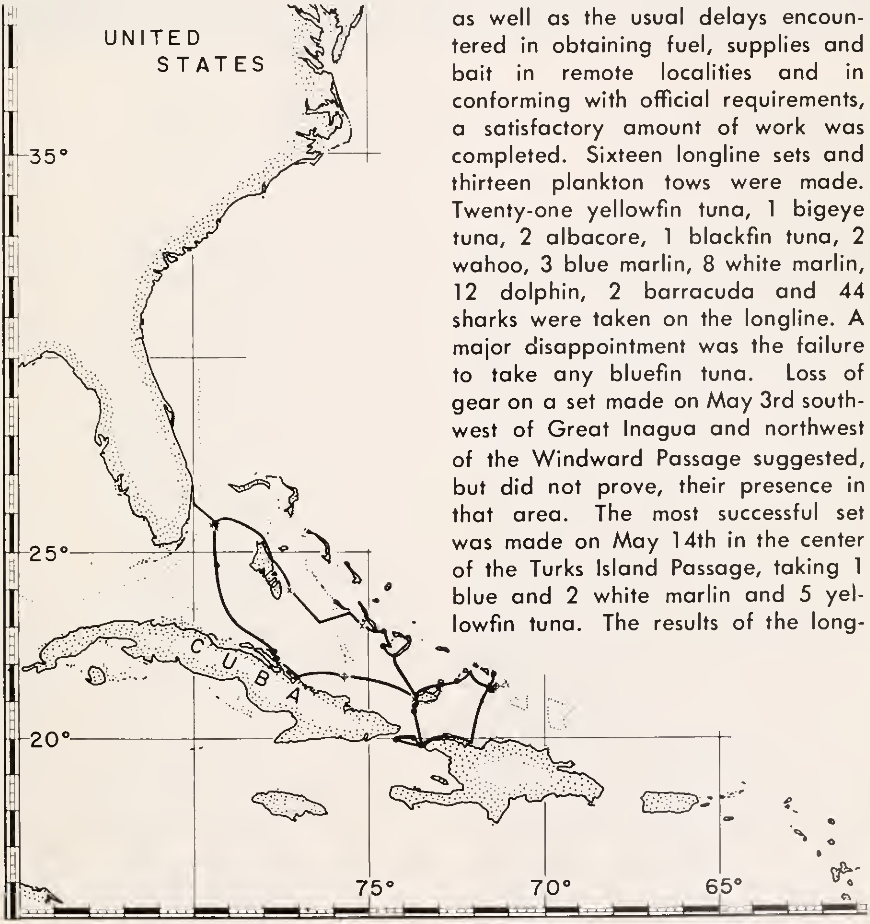
Tracing big game fishes from the Caribbean to the Atlantic.

DURING a cruise of the U.S. Fish and Wildlife Service M/V "Oregon" in April, 1955, concentrations of giant bluefin tuna, albacore, and yellowfin tuna were discovered in the Windward Passage and its southern approaches. Also, the first western Atlantic record of bigeye tuna was obtained off the south coast of Hispaniola. These results were described by Harvey R. Bullis, Jr. of the Fish and Wildlife Service and the author, who participated in the cruise as a guest.

A cruise to explore the distribution and movements of the larger pelagic fishes in the southeastern Bahamas, and off northern Haiti and northeastern Cuba was carried out this spring. The cruise was sponsored by Lou Marron, who donated the use of his sport fishing yacht "Eugenie VIII" for the trip and, with Mrs. Marron, participated in a portion of the cruise. Scientific work was conducted by the author and Donald S. Erdman, leader of the Dingell-Johnson Project in Puerto Rico.

The present cruise was planned to trace the possible movements of the fish toward the Atlantic. In particular, it was hoped to find a connection with the annual northward run of giant bluefin tuna in May and early June off Cat Cay in the northwestern Bahamas. Measurements and counts for use in biometric studies were taken from the specimen's habits and condition of gonads with respect to spawning. Environmental data gathered included observations of weather conditions,

surface temperature, temperature to 450 feet by bathythermograph, and water transparency. Plankton tows were made to obtain approximate data on the richness of the water and to collect eggs and larvae of the larger fishes. Juveniles were collected by dip netting. Fishing for adults was done largely by use of the Japanese longline, a line in this case about 2 miles long and carrying 130 hooks. The line was suspended from floats so that the hooks, each baited with a fish about 6 inches long were from 15 to 45 fathoms below the surface. Trolling and bottom fishing supplemented the longline when time permitted.



The outer Bahamas cruise of the EUGENIE VIII.

The Catch

Despite unseasonably adverse weather and some mechanical difficulties, as well as the usual delays encountered in obtaining fuel, supplies and bait in remote localities and in conforming with official requirements, a satisfactory amount of work was completed. Sixteen longline sets and thirteen plankton tows were made. Twenty-one yellowfin tuna, 1 bigeye tuna, 2 albacore, 1 blackfin tuna, 2 wahoo, 3 blue marlin, 8 white marlin, 12 dolphin, 2 barracuda and 44 sharks were taken on the longline. A major disappointment was the failure to take any bluefin tuna. Loss of gear on a set made on May 3rd southwest of Great Inagua and northwest of the Windward Passage suggested, but did not prove, their presence in that area. The most successful set was made on May 14th in the center of the Turks Island Passage, taking 1 blue and 2 white marlin and 5 yellowfin tuna. The results of the longline fishing are considered fair in view of the facts that good bait was seldom available and that it was necessary to haul the line by hand.

Some indications of a movement through the passage and channels, or at least a connection between

Please turn to page 22

Excerpts of the log of Aries cruise

Photos by the Editor

10 March: 0230 Wind shifted to West. 0240 Jibed to Port Tack. 0445 C/C to trim. 0458 Resumed base course. (Wind NW at 24 Kts.) 1800 C/C to 352 T. Called all hands. 1815 Mainsail lowered. 1820 C/C to 348T. (Wind 37 Kts. NW) 2200 Radio antenna carried away. 2300 Decks awash. Shipping heavy seas. (Wind NW at 44 Kts.)

11 March: 0400 Hove to. Wind force occasionally storm force. Under staysail and mizzen. (Wind NNW at 52 to 60 Kts.) 0815 Underway on reduced power. C-285T. Secured radio antenna. 2100 Sky overcast. Sea moderating slowly. Discovered water leaking through chain pipes. Secured. (Wind NW 13 - 18 Kts.) 2400 Light variable winds. Sky overcast. (Wind Ne'ly 5 to 9 Kts.

12 March: 0750 Called all hands to set square sail. Lowered forestaysail. 0820 Square sail set. (Wind SW 24 to 30 Kts.) 0900 Like sailing on the point of a pin. Making good time. (Wind SW at 37 Kts.)

No. 1

9 - 16 March 1959

Captain John Gates

0950 Lowered Square sail & Mizzen.
1000 Running on bare masts before whole Gale and very rough seas. Secured decks for Gales. Extra gaskets on sails. (Wind SW at 52 to 60 Kts.)
1200 Barometer falling rapidly. Sea increasing. Running on bare poles. Occasional Hurricane force winds (Wind SW 60 - 68 Kts.)
1800 Very rough quartering sea. Barometer still falling. Wind veering to West. Extremely rough sea. (Wind SW 60 - 68 Kts.) Barometer 29:05)
2100 Shipping heavy seas on deck.
2200 Wind increasing. Sea very rough.
2325 Reduced Engine RPM. Shipping heavy seas. Visibility poor. Heavy rain.

13 March: 0820 Contacted NMY for weather report (Winds 60 to 68 NW)
1000 Fighting heavy seas. Trailed deck lines over stern to hold ship steady.
1100 Hand rail Starboard, aft, carried away. (Wind NW 60 - 68 Kts.)
1200 Fighting heavy breaking seas. Using oil overside. Little effect. Standing 2 hr. Watches.
1500 .Port handrail aft carried away. Sea extremely rough. Breaking on quarterdeck.
1600 Heavy snow storm. Crew getting tired.
1900 Rigged lifelines. 4 Lines trailing.
2200 Snow. Gave orders for everyone not on watch to stay below until called.

(Ed. Note): Times are in 24 hours. C/C to 352T means: Change course to 352° True.

Atlantic and Caribbean populations, were obtained. Aside from sharks, yellowfin tuna (called Allison tuna by sport fishermen) were the most abundant and widely distributed species available to the longline. Those taken in the Turks Island Passage averaged 50 pounds, while those caught to the westward were considerably smaller. This species is not abundant in the Straits of Florida. White marlin were taken at two sets in the Crooked Island Passage at sets off Great Inagua and Cayo St. Domingo south of there, indicating a concentration or possibly a migratory passage in this area. Catches of albacore in the Crooked Island and off Great Inagua link up nicely with those made by the "Oregon" in the Windward Passage.

A bigeye tuna taken off Cayo St. Domingo is the first confirmed record of the species from the Bahamas and a link between Caribbean and western Atlantic records described by the author and Dr. Robert H. Gibbs, Jr. in a recent publication.

> *Mr. Mather,* Research Associate in Oceanography, also is a well-known game fisherman. In 1949 he took the world's smallest bluefin tuna (about one foot long) on rod and reel. His wife Willia accompanies him on many of his investigations and holds several women's angling records.

The food of the larger fishes consisted largely of the young of true pelagic fishes or the pelagic young of shore fishes. The latter were present to a surprising and significant extent. From gonad examination, it seemed that white marlin were approaching spawning condition while blue marlin were considerably further from it. None of the larger tunas (yellowfin, bigeye, albacore or the wahoo) were ready to spawn, but the smaller blackfin tuna, the little tuna (southern bonito) the oceanic bonito and the dolphin were approaching a fully ripe condition.

The results of the exploration of these remote and little-known waters were therefore of considerable interest and the Institution is greatly obligated to Mr. and Mrs. Marron for sponsoring this cruise and for their enthusiastic participation.

Some of the catch. At left, Associate Lou Marron, in shorts: Donald Erdman and Frank Mather.

Gifts and Grants

The following grants were received from the National Science Foundation:

for:	"Procurement of deep water large sample bottles for the continuing U. S. Antarctic Research Program"	$ 2,000
for:	"Composition of oceanic deep scattering layers" under the direction of Dr. Richard H. Backus	$ 58,100
for:	"Design concepts for research vessels" under the direction of Francis Minot	$ 18,400
for:	"Environmental cetology" under the direction of William E. Schevill	$ 56,700
for:	"Operational costs and related expenses in the International Geophysical Year deep current oceanography program in the Atlantic" under the direction of Dr. Paul M. Fye	$ 5,000
for:	"Directional spectrum of water waves" under the direction of Harlow G. Farmer	$ 24,000
for:	"Biology of the larger pelagic fishes of the western Atlantic" under the direction of William C. Schroeder	$ 65,000
for:	"Analysis of Oceanographic data in the International Geophysical Year inter-disciplinary research program" under the direction of Dr. Paul M. Fye	$ 60,000
for:	"Atmospheric convection, and its role in tropical meteorology" under the direction of Dr. Joanne S. Malkus	$156,100
for:	"Sea-salt nuclei — their origin, physical-chemical nature and role in atmospheric processes" under the direction of A. H. Woodcock	$ 83,100
for:	"Ship operation costs for basic biological oceanographic research" under the direction of Bostwick H. Ketchum	$250,000
for:	"Collaborative study of deep ocean current systems", under the direction of Henry M. Stommel	$290,000

From the Esso Education Foundation .... $ 3,500

From the Alfred P. Sloan Foundation

for: Fellowship support .... $ 10,000

From the U. S. Steel Foundation

for: Basic research in oceanography .... $ 5,000

From Scullery to Front Parlor

By David H. Frantz, Jr.

"BUOYS have become respectable." This pronouncement was made recently by Columbus O'D. Iselin, former Director of the Institution and a member of the National Science Foundation's Committee on Oceanography whose report "Oceanography, 1960 to 1970" has highlighted in the public mind the significance of oceanography as a natural science worthy of national support. What is the significance of buoys in the study of the seas, and why is it that an apparent ascent from the scullery to the front parlor has taken place? The development of buoys received prominent mention in the report. What makes a buoy respectable?

A buoy, as a scientific tool, is a floating, unmanned object which functions as a useful and economical adjunct to a research vessel. A sure criterion of respectability is that either individually or collectively it provides believable data; and an only slightly less valid one is that it give promise of providing such data after the expenditure of a reasonable development effort. Instrumentation for an earth science such as oceanography,

in which measurements are made largely in the field, has one characteristic that places it in a class apart from apparatus, however sophisticated, which functions in the well-equipped laboratory ashore; it must function reliably within its intended limits of accuracy under extremely adverse conditions. These conditions are at their worst at or near the sea-surface, and even though we may be interested in making measurements in the comparatively serene depths, we must always get our device to the location, usually on a ship on the surface of the sea, and then we must get it safely off the ship and through the sea-surface. In classical physical oceanography, whose most famous tools are the Nansen bottle and reversing thermometer, we see the effect of the rigorous environment on instrument design. A good reversing thermometer can be believed; if it has suffered damage sufficient to make it unreliable, it is probably a broken thermometer. A string of Nansen bottles and the winch to lower it is heavy, clumsy, and expensive but given reasonable care it is extremely reliable and can be used in sea conditions which may be far from perfect. But these devices are used by men, and read and adjusted by men. When we speak of buoys and the devices to be mounted on them, we are adding another order of magnitude to the problem of reliable design; that it must function after transportation on the surface of the sea, deck handling and getting over the side, and then continue to function when beyond all chance of adjustment and repair.

Accomplishments

How have we been doing in producing buoys which function with the reliability necessary to give us useful information about the oceans? If the function is simple enough, we have done well. The most simple buoy has been used for at least a hundred years and is still being used, the ballasted drift bottle. By virtue of its small size it survives the worst the sea alone can do to it, and a surprising number survive the ultimate landing, to be found, and reported. Much valuable data on mean surface currents has been collected by this means, but this buoy is reliable only when considered collectively; any one bottle has a small chance of return, and any one return is of itself quite unreliable but must be considered in relation to many others. Nevertheless, within its limitation, it is a respectable buoy.

A buoy of much more recent design than the drift bottle is the Woods Hole telemetering drift buoy. This was conceived as the basic element of a system of data gathering and transmission by radio, but its real contribution to date has been its use in the investigation of surface currents by our Oceanographer Dean Bumpus, in the Bay of Fundy, on Georges Banks, off the coast of Massachusetts, and in Onslow Bay, North Carolina, all areas of interest in fisheries research. These buoys are put out at selected locations in the area being studied and allowed to drift with the surface currents for as long as several weeks. Their unique characteristic is that they listen continuously by radio for an appropriate signal, and when this signal is transmitted by ship or plane, the buoy makes a short transmission, usually a call-sign in code followed by a long dash, by means of which a ship or airplane can obtain a radio bearing. Thus it is possible to locate these buoys periodically during the course of an experiment with the ship. The data are akin to drift bottle data but we know the route and times be-

tween the point of recovery, information that is always in doubt with an individual drift bottle.

A third buoy which has been used to produce significant results is the "submerged drift-bottle" or Swallow float, a unit developed by Dr. John Swallow, of the (British) National Institute of Oceanography for the study of the deep currents in the ocean. Except for the facts that it operates submerged and uses acoustic signals rather than radio, it is very closely related to the surface buoy described above. Both require the quite close attendance of an observer, and neither gives any information other than its own location.

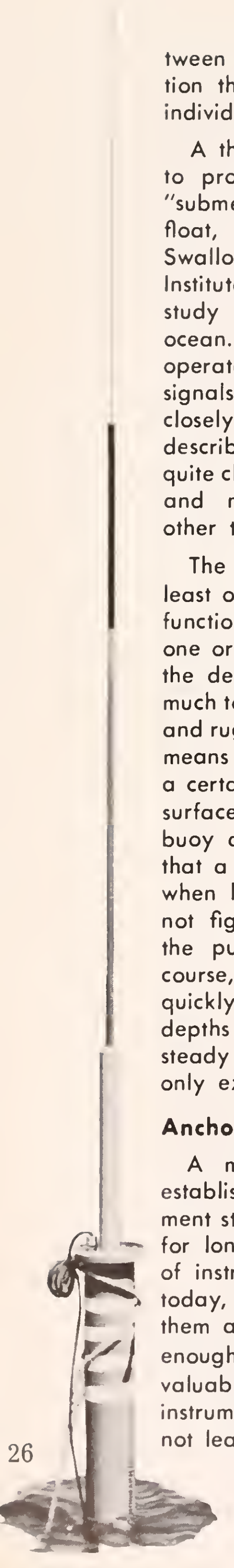
The three examples above have at least one thing in common; they have functioned successfully on more than one or two occasions. Two factors in the design of each have contributed much to this success; each is as simple and rugged as it is within our present means to make it, and each avoids to a certain extent the rigors of the sea-surface. The drift bottle and the drift buoy are very seaworthy in the way that a small, strong ship is seaworthy when hove-to; i. e., these devices do not fight wave action but give with the punch. The Swallow floats, of course, get through the surface very quickly and descend to the quiet depths where corrosion and the steady pressure of salt water are the only external enemies.

Anchored Buoys

A more difficult problem is the establishment of an unmanned instrument station in a fixed location at sea for long periods of time. A number of instruments for such stations exist today, and we believe that many of them are simple enough and rugged enough to perform satisfactorily. Little valuable data have come from such instruments as yet, because we have not learned how to keep them where they belong and to get them when we want them. There is no doubt that a large buoy can be maintained in deep water through the worst weather and presumably for long periods of time; the submarine cable companies have done it for years, but most oceanographers feel that while there is a place for the large instrumented buoy station, not only economics but sheer lack of capacity of available vessels makes them impractical for any program requiring more than a few stations, so we must be able to keep a small (1,000 pounds or less) buoy on station in deep water in the worst weather as well. In the calmer regions of the ocean such buoys have been maintained for considerable periods, but the North Atlantic in the wintertime is our testing area, and while the number of attempts to date has been too small to be statistically significant, we know we have a long way to go.

J. H.

Drift bottles going on their way from the R.V. CARYN.



A telemetering drift buoy

One of the promising types is a Woods Hole development of the basic drift buoy described above. It has added displacement, for greater buoyancy, and like the basic buoy it is designed to transmit on demand. As well as the locating signal, however, it can send quantitative information on temperatures, currents, weather conditions, etc., for a distance of at least 150 miles. These devices have not yet achieved "respectability" in that they have not been incorporated in a scientific program, but tests, while in each case revealing some weakness, have been promising.

Another buoy designed to stay on station until called is the Instrument Recovery Buoy*. This avoids the troublesome sea surface by descending below it, hauled down by its anchor and returns to the surface where it transmits a radio signal for final recovery. Where only subsurface data are required this may well prove to be the more convenient and economical approach, since it need not have the stamina to take the pounding of waves, but in its relatively favorable submarine environment it still must maintain absolute reliablity for successful recovery. Testing of apparatus such as these is time consuming and frustrating, since under actual field conditions opportunity for a post-mortem on any failure is generally non-existent.

There are other technical fields in which problems of no lesser magnitude than those we face have been overcome, given sufficient incentive.

* See: "New Instruments", Oceanus, Vol. II, no. 20.

Mr. Frantz, Research Associate in Engineering, knows first hand what type of weather his buoys have to withstand. He was on board the Aries cruise from Bermuda this spring.

The design of reliable electronic apparatus for function under adverse conditions has been very successful in certain fields. For instance, communications and radar equipment developed under the stimulus of military necessity. Another example may be found in the fine, accurate oscillographs which became available through the demands of oil-well prospecting. These particular examples have been adopted successfully by oceanographers and now rank almost with the Nansen bottle in reliability. However, in terms of technical manpower alone, the effort devoted to strictly oceanographic instrumentation, and particularly to the design of the platform on which to mount the instruments have been almost infinitesimal compared to that which has gone into even one class of device mentioned above, military communications equipment, for example.

The oceanographic buoy station has become respectable in that it is obvious that the problems are not monumental compared to similar ones that have been solved in other fields. Unmanned stations still have to attain that full measure of respectability which will come when scientific programs using the devices in considerable number can be planned with good prospect of success by oceanographers, not by instrument designers.

The Salinometer

By Karl E. Schleicher

For many years oceanographers have brought back thousands of water samples to be titrated chemically for their salinity content. Now, salinity can be measured on board ship with greater precision and with a great saving of time.

THE idea that the electrical conductive properties of sea water might be used to determine salinity was first suggested by Karsten in 1897. Though the years immediately following saw rapid advance in techniques and apparatus concerned with conductivity measurements in general, it was not until 1922 that a really successful conductivity bridge was built — designed specifically for the routine determination of salinity on board a research ship. This instrument was designed and built by the Bureau of Standards for the U. S. Coast Guard. Since then several other models were constructed and the last one of this series has been in use successfully for many years by the U. S. Coast Guard on its annual Ice Patrol cruises.

Other instruments based on conductivity measurements but designed to record salinity or other related properties of sea water continuously have been used in more recent years at the Institution and elsewhere. These instruments were, for the most part, extremely useful in the job for which they were designed but because of the difficulties inherent in in-situ measurements none of them could match the precision of the Coast Guard type of bridge which was designed to determine the salinity of single samples as taken from Nansen Bottles. As far as the writer is aware it was not until 1954, when the first of the Woods Hole Salinometers was built, that another instrument comparable to the Coast Guard Bridge was used as a routine method of finding salinity on board ship.

The electrical conductivity of sea water, (its ability to conduct electricity) is dependent on its salinity and its temperature. There is also a pressure dependence but since all measurements made by the salinometer are at atmospheric pressure we need not concern ourselves with this relationship. Furthermore it has been found that for most practical purposes, the conductivity-salinity-temperature relationship is unique and is independent of the geographical location of the source of the sea

water samples. It is evident then that once this relationship has been determined we can find the salinity of any sample by measuring its conductivity and temperature. If high accuracy is desired, however, this direct method is not very satisfactory due to the difficulties in absolute measurements of both the conductivity and temperature to the precision required. To avoid these difficulties the salinometer makes use of a "standard" sample of water whose salinity is known and compares the conductivity of this water to that of the unknown sample at the same temperature.

J. H.

GEORGE BOLTZ

AT SEA and in the laboratory the salinometer has proved its value during recent years.

The Instrument

Physically, the new model of the Woods Hole Salinometer is slightly larger than a standard four drawer office filing cabinet. It can be dismantled easily for transfer from ship to ship or ship to shore. It is divided into three main units: the bridge unit, the "heart" of the instrument which does the comparing of the conductivities as mentioned above; the bath unit which is a constant temperature oil bath to keep the sea water samples at a temperature of 15°C; and the electronic gear necessary to run the instrument.

There are now four salinometers at Woods Hole. The original No. 1, built in 1954, is more or less retired to shore duty after having been on seven cruises during which almost 9,000 samples were analyzed. This instrument does not have a refrigerated bath nor is it as automatic as the newer models. Also not being as compact as the others it is less convenient to take to sea. On the other hand it is more versatile—being able to analyze water from about 16 o/oo to 40 o/oo* instead of the more limited range of

* Salinity is essentially a measure of the total quantity of dissolved solids in a given sample of sea water and is given in units of parts per thousand by weight (o/oo.) The average salinity in the open ocean is about 35 o/oo.

salinometers 2, 3, and 4, of 30 o/oo to 40 o/oo. It is therefore the best of the four instruments to keep on shore where there is often the need to analyze samples of low salinities taken from inshore waters.

The last of the salinometers, No. 4, was finished in November 1958 and is now on its maiden cruise on the VEMA of the Lamont Geological Observatory in the southern Atlantic.

Altogether the salinometers have been on 14 cruises (of six different vessels) not counting the ones they are on at present. On these cruises a total of more than 17,500 salinity samples have been analyzed. The number of samples that have been analyzed on shore by the instruments is not known too well but there have been at least 16,000. Most of these have been analyzed on salinometer No. 1. There have been approximately 14 different operators of the salinometers including two Germans who operated No. 3 for a month while it was on loan to the German Hydrographic Institute in Hamburg.

Great Precision

The two most obvious advantages of a salinometer over the chemical Knudsen titration for determining salinity is the increase in precision (about five times) and the much greater ease of operation at sea. With the greater precision available it is possible to differentiate between two water masses so close together in salinity-temperature characteristics

> *Mr. Schleicher,* Research Associate in Physics, has made many cruises on our ships and last summer sailed on the German R.V. ANTON DOHRN to Icelandic and west Greenland waters.

that the scatter in the titration method would prevent their separate identification. This opens up many new possibilities in the investigation of deep ocean waters. The ease of operation at sea now makes it practical to have all salinity data worked up before the cruise is over. Indeed, if desired, the data on any one station may be completed within an hour or two of gathering the samples and the results may help the oceanographer in deciding upon the plans for the following station. This may gradually change the planning technique of future hydrographic cruises which till now have been essentially of the survey type where the location and most of the details of the stations have been decided upon before the cruise starts. It should be mentioned that titration has been done at sea and in some cases still is. However, it is relatively difficult and takes so much skill to get reasonable results that it is not done as a general practice. With the salinometer, analysis at sea can be done with as much speed and as good precision, even in moderately rough sea conditions, as on shore, assuming that the operator himself is not overly affected by the motion of the vessel.

Potheads

JAN HAHN

THREE POTHEAD WHALES (Globicephala) lazing at the glassy surface near "Atlantis" early on an August morning last year in the western Mediterranean.

They were members of a large group swimming between the U.S.C.G. YAMACRAW and the "Atlantis" while the ships were waiting early in the morning to start the day's program of seismic exploration. Dr. Richard H. Backus and some companions put out in a rubber boat and approached close enough to touch the whales, and for nearly an hour observe their behavior at close quarters.

The Swallow Buoy

By Gordon H. Volkmann

Direct measurements of sub-surface currents were made possible with a simple, reliable device.

THE Pinger developed by Dr. John Swallow at the (British) National Institute of Oceanography for the measurement of deep current uses the difference between the compressibilities of aluminum tubing and water as the depth stabilizing element. In other words the tube is less compressible than water. As it sinks into the ocean it gains buoyancy. By careful calibration its overall density can be adjusted to correspond to the density at any given depth in the ocean and there the pinger will become neutrally buoyant and drift with the current at that depth. While this relative incompressibility is fairly common among structural materials, aluminum has a feature not so common. It can be made of sufficiently heavy stock to withstand the pressures encountered in the deep oceans and at the same time remain lighter than water so that it can carry a pay load.

The tubes under development at Woods Hole are 4 inches in diameter with a wall thickness of 0.312 inches. They are 8 ft. long and can carry a pay load of 8 pounds to a depth of 25,000 ft. This is sufficient to reach the bottom of the ocean everywhere except in the deep trenches.

The pinger has inside it a simple electronic device similar to the electronic flash used in photography to send current through a coil wrapped around a nickel ring outside the tube. This nickel ring then produces a noise by the commonly used "magnetostrictive effect." This is the "ping" of the pinger and is used for tracking it. Heard in the air it is an unimpressive sound and probably wouldn't be noticed even at a small cocktail party. But in the ocean where this seems to be an unusual sound and where sound transmission is much better it can be heard 3 to 4 miles.

IGY

The Swallow buoy and some areas where subsurface currents have been detected with its aid.

The simplicity of design both structurally and electrically of course enhances its reliability.

The pinger has already been used in a wide variety of places. It was first used off the coast of England where it showed tidal oscillations at middle depths. The next series was the now famous experiment off the Carolinas where it showed the deep flow under the Gulf Stream.* Swallow has also used pingers in various parts of the North Pacific and in the deep water west of Spain. During the next year Dr. Swallow will use pingers to study subsurface currents in the middle of the ocean with the aid of our newly acquired R.V. ARIES which will be stationed at Bermuda during that period.

* See: Oceanus, Vol. V, nos. 3 & 4.

Sediments and Turbidity Currents.

by Richard G. Leahy

Bottom sediments off South America were influenced by deposits from the Amazon and the Rio de la Plata.

As part of the current ATLANTIS cruise to the South Atlantic, a geological investigation was carried out in the western basin between the latitudes of Rio de Janeiro and Buenos Aires. This work and the general hydrographic program of Mr. Arthur Miller, chief scientist on the ATLANTIS, are part of the Institution's program for the International Geophysical Cooperation of 1959, the continuation and windup of the International Geophysical Year.

The original interest in the geology of the bottom sediments in this area was instigated by the general lack of any previous data from this area and from the supposition that the area might present an uncomplicated sedimentary record which could be utilized for analyses designated to investigate the paleoclimatic record for these latitudes. For this purpose it was hoped that the sediment would be completely oceanic in nature and would be the result of a very slow rate of deposition measured in centimeters per thousand years such that long term climatic trends could be expected to be reflected in a vertical section through the sediments. A section of slowly accumulating sediment would also be useful for a second problem which was concerned with the diffusion and distribution of naturally occurring trace elements and the change in the chemical content of the water in the sediments with depth in the core.

A third problem related to the changing problem related to the changing thorium content of the surface sediments with changing salinity conditions and it was planned to take samples across the shelf and into the fresh water sediments of the Rio de

R. G. MUNNS

The piston coring tube alongside the ATLANTIS ready for a lowering.

Dr. Leahy and Richard Edwards cutting and preserving the sediment.

Chief scientist A. R. Miller at the Woods Hole precision recorder.

R. G. MUNNS

la Plata. To permit the special geochemical analyses which were necessary to resolve these problems, elaborate sampling techniques were developed to extrude and section the core to prevent chemical contamination and to squeeze the interstitial water from sediment samples.

R. G. MUNNS

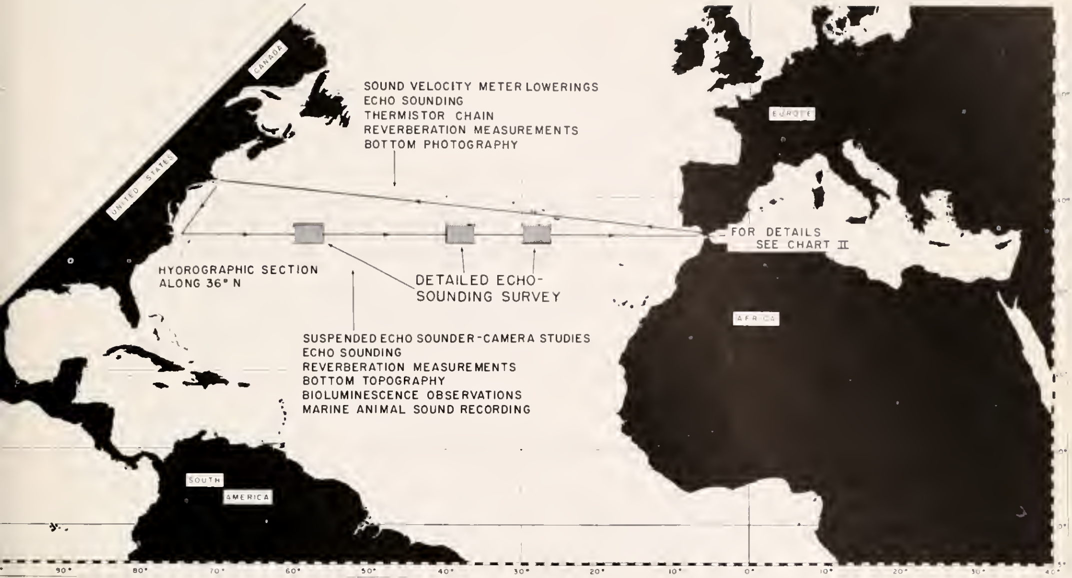
The preliminary examination of the sedimentary material carried out while the cores were being sampled on board the ATLANTIS indicated that a much different depositional picture existed in the area than was hoped for when the project was orginated. A core taken in over 15,000 feet of water 1,200 miles east of the mouth of the Rio de la Plata demonstrated many of the characteristics indicative of turbidity current desposition. Rather than being the product of a slow relatively uniform depositional process, turbidity current deposits are considered to form

catastrophically with several feet of sediment being accumulated within hours. The source of these sediments is postulated to be some higher topographic area such as the edge of the Continental Shelf where a river may be dumping material by normal processes. This sediment piles up unstably due to its topographic position, fast rate of supply and high water content where it remains until the submarine slide is triggered by some mechanism such as an earthquake or a major storm. When the submarine slide begins, the material slips down the slope and picks up velocity until it finally reaches a basin where the sediment is redeposited, the coarser material, having travelled faster, is on the bottom of the bed and grades into finer sediment above. Due to this banding and other depositional features, distinct cycles can be recognized and four or five were noted in a twenty foot core from this South Atlantic area. It has been suggested by some geologists that these turbidity slides and currents achieve sufficient densities to erode the submarine canyons that are known in Continental Shelf areas and to reach velocities of over sixty miles per hour. Although these extreme views are not generally held, they indicate the nature of this phenomenon.

The occurrence of this type of deposit in the region under investigation proved disappointing in light of the proposed research program which was dependent upon the discovery of an area of slowly accumulating oceanic sediments such as an area known in the central Pacific. The rapidly accumulating sediments found, fit the depositional picture for what is known for the rest of the Atlantic basin between the mid-Atlantic Ridge and North and South America. The present rate of supply of sediment by rivers such as the Rio de la Plata and the Amazon and the former rate of such North American rivers as the Hudson during glacial times have contributed tremendous volumes of sediment to the western Atlantic. This material is found all the way to the base of the mid-Atlantic Ridge between the limits of sea ice in both the northern and southern hemisphere.

Dr. Leahy is assistant to the Director. He has been responsible for the co-ordination of our IGY efforts and is interested in the CO_2 cycle and other geochemical problems.

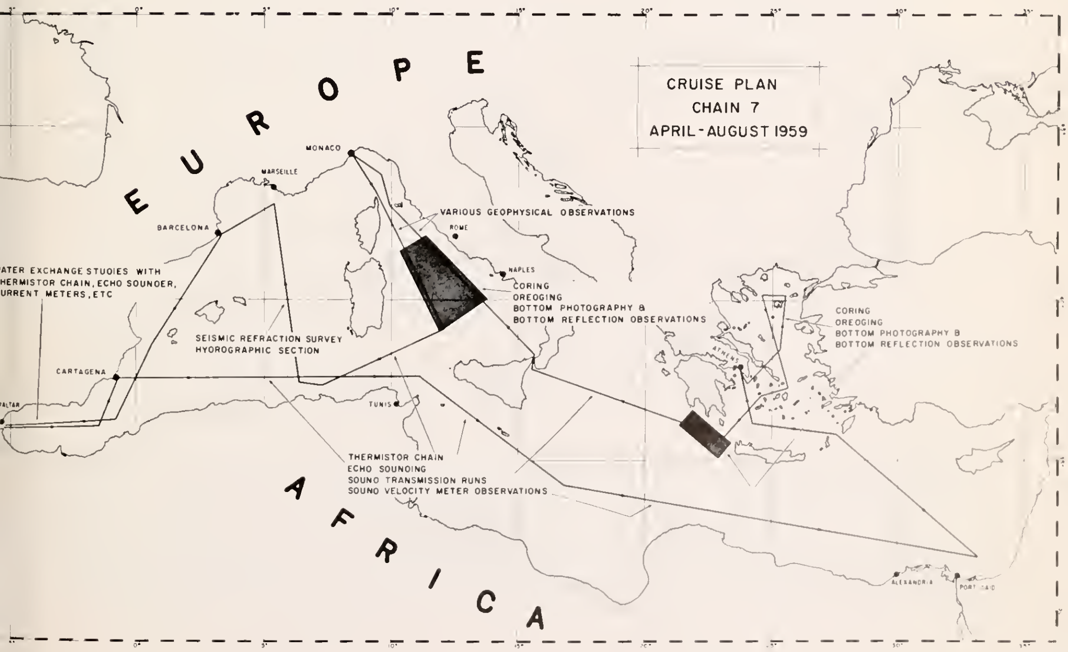
Where are the ships?

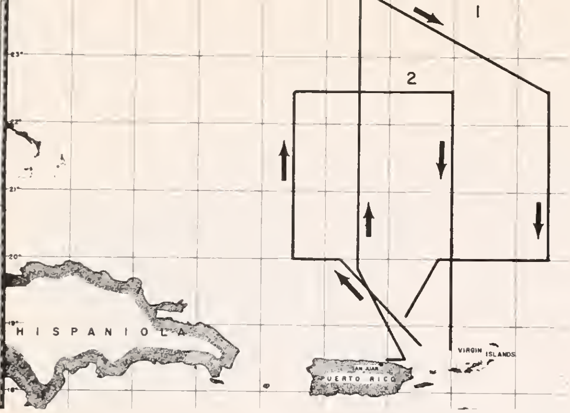


C. INNIS

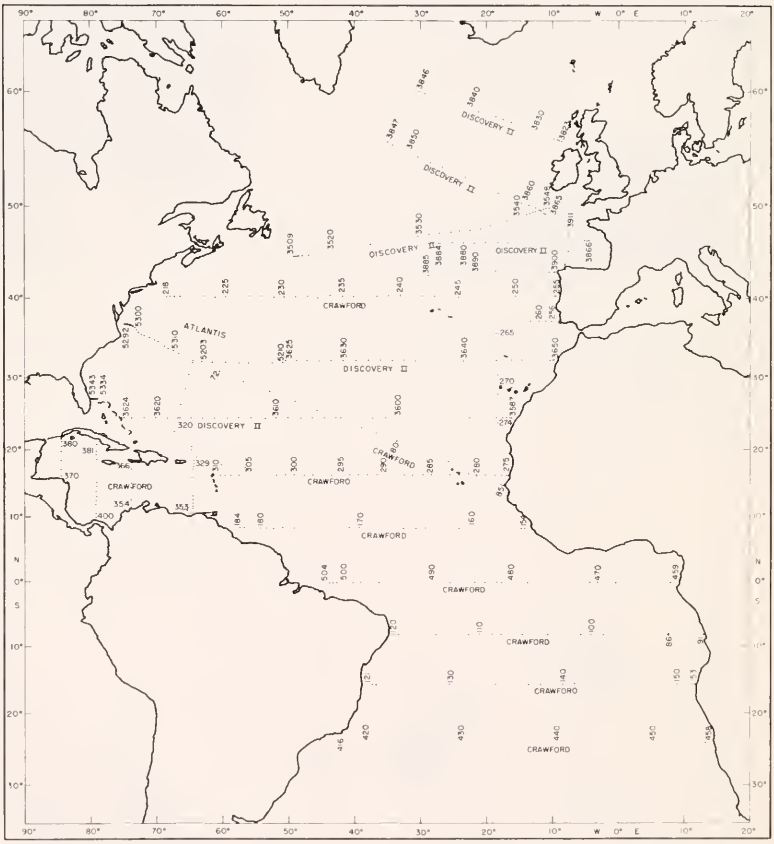
The CHAIN (Capt. W. S. Olivey) left in April on a four months cruise in the Mediterranean for Dr. J. B. Hersey's geophysical group and students.

C. INNIS





The BEAR (Capt. H. H. Seibert) participated in the "Mohole" survey; a seismic reconnaisance to determine if the area shown, off Puerto Rico, is suitable for an attempt to drill through the crust of the earth.



The ATLANTIS (Captains, W. S. Bray, R. Colburn and E. Mysona) finished the southernmost section (32° S.) in June. The small CRAWFORD (Capt. D. Casiles) has done the lion's share of the work made in conjunction with the (British) National Institute of Oceanography. Each dot represents a "hydra station" where observations were made of temperature, salinity, oxygen, phosphate and other properties, from the surface to the bottom. Complete bottom profiles and other data were also obtained. Not shown are stations occupied in the Indian Ocean, Red Sea and Mediterranean.

Fellowships

ELEVEN SUMMER STUDENT Fellowships were awarded this Spring by the Institution. The Fellowship program, which is now in its 29th year, gives students an opportunity to pursue advanced studies in oceanography under the supervision of the Institution's staff. No degrees, credits, examinations or grades are given, although a certificate of accomplishment may be issued.

"We consider the Fellowship program one of our most important activities and are proud that many men and women now engaged in scientific research once were our Fellows," said Paul M. Fye, Director of the Institution. "Oceanography is expanding rapidly. We need the brains and drive of present day students to aid in our aims to describe, understand and eventually predict natural occurrences so that man may learn to make full use of his environment rather than be ruled by it."

The Education Policy Committee, consisting of Drs. B. H. Ketchum, V. T. Bowen, W. S. von Arx, J. B. Hersey and Joanne S. Malkus, received 98 applications from students in 22 schools in the U. S., India, Japan and Sweden. Recipients are:

Mr. Robert A. Berner, Harvard University; Mr. John Charles Gille, Massachusetts Institute of Technology; Mr. Edward H. Green, Massachusetts Institute of Technology; Mr. Donald James Hall, University of Michigan; Mr. William S. Maddux, Rutgers University; Mr. Thomas Owen Phillips, Princeton University, Mr. Robert A. Phinney, Massachusetts Institute of Technology; Dr. Edward A. Spiegel, University of California (Postdoctoral); Mr. Lynn Ray Sykes, Massachusetts of Technology; Mr. B. Samuel Tanenbaum, Yale University; Mr. Thomas F. Webster; Massachusetts Institute of Technology.

Rossby Memorial Fellowship

The Carl-Gustaf Rossby Memorial Fellowship was established by the Board of Trustees of the Institution as a fitting memorial to our Senior Meteorologist. Preference will be given to applicants interested in those many areas of study which engaged Professor Rossby's attention. The American Meteorological Society was invited to name the first Rossby Fellow. Dr. P. M. Saunders of the Imperial College of Science and Technology (University of London) was selected and will arrive in Woods Hole this fall.

Swedish-born Carl-Gustaf Rossby, world famous meteorologist, (1899-1957) had been associated with our Institution since its beginning. His drive and uninhibited enthusiasms are sorely missed. His last project: to bring meteorology into close relationship with oceanography, is succeeding and will be forwarded through the Rossby Fellowship.

Currents and Tides

The report "Oceanography 1960-1970" of the National Academy of Sciences — National Research Council, has received widespread attention. It was, therefore, deemed not necessary to discuss it in this issue. Copies of the report were sent to the Associates.

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"The Gulf Stream"—a physical and dynamic description — is the title of a book by Henry Stommel, published recently by the University of California Press.

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A Conference on Physics of Precipitation was held at the Institution on June 3-5, 1959. Arranged by the cloud physics committee of the NAS-NRC, this was the second conference at Woods Hole. The first conference (September, 1955) led to the publication of a book, "Artificial stimulation of rain". Pergamon Press, New York, 1957.

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Working for 15 hours on end in the hot equatorial sun and through the humid night, scientists and crew of the CRAWFORD worked to bring some 10,000 feet of wire with 11 Nansen bottles back on board. The winch had broken down two days out of Rio de Janeiro, during the IGY crossing along 24° South.

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The Printing and Publications Office of the National Academy of Sciences, 2101 Constitution Avenue, Washington, D. C. brought out a magnificent set of six IGY posters, including one: "The Oceans". The price per set is $5.75, available at the above address.

Most of our IGY observations have been submitted to the World Data Centers in record time. Hard work on the part of the scientific participants and the salinometer (see page 28) made this possible.

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The ATLANTIS and the CHAIN are scheduled to be at New York during the International Oceanographic Congress at the United Nations from August 31 to September 12th.

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A 16 mm sound projector was given to the officers and crew as a reward for their efforts. Chief scientist Wm. G. Metcalf stated: "We at the Institution recognize the part the CRAWFORD has played during the IGY. It is to the credit of the crew as much as anyone's that our IGY work was so successful."

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An advanced program for our Industrial Associates and others was held last fall at the Institution. A one week course was presented by staff members: "Environmental factors influencing the performance of naval weapon systems."

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One outcome of our Fellowship program was the description of one new genus of squid and two new species. Gilbert L. Voss of the Marine Laboratory of Miami University, the recipient of the Fellowship, studied the mollusks collected by Richard H. Backus on the ATLANTIS during a West Indies cruise in 1954.

One of the two new species (*Selenoteuthis scintillans*) was described: "—must rank among the most brilliant of our luminous bathypelagic species."

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